

continued motion of a single contact. Thus, in some embodiments of the invention, a smoothing capability may be added to address intermittent loss of contact. Specifically, a minimum time may be required before a termination of a contact is acknowledged. That is, if the touch sensor reports that position information is no longer available for contact C1 or C2, and then shortly thereafter reports a new contact in the immediate vicinity, the new contact may be considered a continuation of the prior contact. Appropriate thresholds of time and distance may be used to ascertain if the new contact is, in fact, merely a continuation of the previous contact.

[0032] FIG. 3 shows a schematic representation of the gesture identification module behavior. The behavior of the gesture identification module is best considered as a series of transitions between a set of possible states. Upon receipt of updated contact information from the touch sensor, the gesture identification module determines, based on the initiation, termination, and motion of the contacts, whether it transitions into another state or remains in the current state. Depending on the current state, the gesture identification module may also identify a user gesture and send an appropriate display command to the display control module.

[0033] Upon initialization, the gesture identification module enters the Idle state (3000). In the Idle state, the gesture identification module identifies no gesture and issues no display command to the display control module. The gesture identification module remains in the Idle state until the initiation D1 of a first contact C1. Upon initiation D1 of a first contact C1, the gesture identification module enters the Tracking One state (3010).

[0034] In the Tracking One state, the gesture identification module identifies no gesture and issues no display command to the display control module. However, the gesture identification module continues to monitor the contact C1. If the first contact is terminated U1, the gesture identification module enters the Clicking state (3020). If motion M1 of the first contact is detected, the gesture identification module enters the Awaiting Click state (3030). If the initiation of a second contact D2 is detected, the gesture identification module enters the Tracking Two state (3060). Otherwise, the gesture identification module remains in the Tracking One state.

[0035] In the Awaiting Click state, the gesture identification module identifies no gesture and issues no display command to the display control module. However, the gesture identification module continues to monitor the behavior of the first contact and awaits a possible second contact. If the first contact is terminated U1 within a predetermined time period $66\ t_c$, the gesture identification module enters the Clicking state. If a second contact is initiated D2 within the predetermined time period Δt_c , the gesture identification module enters the Tracking Two state. If the first contact is not terminated and a second contact is not initiated within the predetermined time period Δt_c , the gesture identification module enters the Assume Panning state (3040).

[0036] In the Clicking state, the gesture identification module identifies a clicking gesture and issues a click command to the display control module, that, when executed by the display control module, provides a visual confirmation that a location or object on the display has been designated.

[0037] In the Assume Panning state, the gesture identification module identifies no gesture and issues no display command to the display control module. However, the gesture identification module continues to monitor the behavior of the first contact and awaits a possible second contact. If the first contact is terminated U1 within a predetermined time period Δt_p , the gesture identification module returns to the Idle state. If a second contact is initiated D2 within the predetermined time period Δt_p , the gesture identification module enters the Tracking Two state. If the first contact is not terminated, and a second contact is not initiated within the predetermined time period Δt_p , the gesture identification module determines that neither a click nor a gesture requiring two contacts is forthcoming and enters the Panning state (3050).

[0038] In the Panning state, the gesture identification module identifies a panning gesture and issues a pan command to the display control module that, when executed by the display control module, translates the displayed imagery. Generally, the pan command specifies that the imagery be translated a distance proportional to the distance the first contact has moved M1 between the previous and current updates of the first contact position C1. Preferably, the translation of the imagery, measured in pixels, is equal to the movement of the first contact, measured in pixels. This one-to-one correspondence provides the user with a natural sense of sliding the imagery as if fixed to the moving contact location. If the first contact is terminated U1, the gesture identification module returns to the Idle state. If the first contact continues to move M1, the gesture identification module remains in the Panning state to identify another panning gesture and issue another pan command to the display control module. Panning thus continues until one of the contacts is terminated.

[0039] In the Tracking Two state, the gesture identification module identifies no gesture and issues no display command to the display control module. However, the gesture identification module continues to monitor the behavior of the first and second contacts. If either the first or second contact is terminated, U1 or U2, the gesture identification module enters the Was Tracking Two state. Otherwise, the gesture identification module determines if the motions of the first and second contact points M1 and M2 are aligned or opposed. If the contact points exhibit Opposed Motion, the gesture identification module enters the Zooming state (3070). If the contact points exhibit Aligned Motion, the gesture identification module enters the Panning state. Aligned Motion thus results in two contacts being treated as one in that the behavior of the second contact is ignored in the Panning state. This greatly alleviates the problems encountered when a user attempts to gestures with his entire hand. As noted previously, a user often believes he is contacting the touch sensor at a single, hand sized region but, in fact, establishes two separate contact points as determined by the touch sensor.

[0040] FIG. 4 shows the classification of contact motion as aligned or opposed. Before the distinction between Opposed Motion and Aligned Motion can be determined, motion of both contacts, M1 and M2, must be present. The motions M1 and M2 are considered aligned if the angle between the motion vectors 321 and 322 is less than a predetermined angular threshold. This calculation is preferably performed by considering the angle of the motion vectors relative to a